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Increasing the fire resistance of existing timber floors

This digest explains how the fire resistance of existing floors can be increased to periods of up to one hour. It discusses the addition of protection to the underside of the ceiling, over the floor boarding and between the joists, and the problems of improving fire resistance when the joists are to be exposed to view from below. Floors which are improved as described should generally give a satisfactory standard of fire performance but the precise improvement depends on the details of construction and the condition of the existing floor. The final decision as to suitability must rest with the building or fire authority.

Because this digest can give guidance only of a general nature, few jobs will fall precisely into the simple examples that are given (joist sizes and spacing may differ for example) and expert advice will have to be sought. In most cases, therefore, it can merely alert the reader to the problems that may be met.

The principal revisions in this new edition are to Tables 1 and 2 and are the result of further work carried out by the Fire Research Station and changes in the characteristics of premixed lightweight plasters.

Where there is an alteration, extension or material change of use of a building, regulations may require the period of fire resistance of existing timber floors to be increased. As with other structural elements, the fire resistance of a floor depends upon it satisfying criteria for specified periods. They are:

stability: the resistance to collapse or excessive deflection under load

integrity: the resistance to the formation of cracks or gaps which could lead to fire spread

insulation: the ability to restrict excessive transmission of heat.

Normally the floor should satisfy all criteria for the full period, but Building Regulations also prescribe a 'modified half-hour' floor for small houses which must satisfy the stability criterion for thirty minutes and the integrity and insulation criteria for fifteen minutes.

The method of test for floors is exposure of the underside to fire and therefore the fire resistance of timber floor constructions depends primarily on the protection given by the ceiling; once a ceiling has been penetrated the joists and underside of the floor boarding become exposed to fire. Although the fire resistance of an element of construction applies to the complete assembly, the stability of any individual member supporting a fire-resisting membrane must be considered. Plain-edged floor boarding or tongued and grooved boarding with significant shrinkage contribute little and the period of fire resistance of the floor is effectively the collapse time of the ceiling membrane. Tongued and grooved boarding with closed joists or added surfacing can contribute additional time to integrity and insulation.

The addition of a hardboard or plywood surface enables a plain-edged boarded floor (or sub-standard tongued and grooved floor) to be considered as a good-fitting tongued and grooved floor construction for the purposes of its maximum contribution to integrity and insulation. Although existing lath and plaster ceilings may possibly contribute as much as twenty minutes or so to the fire resistance of a timber floor, this will depend on the condition and key. Greater thicknesses of plaster will not necessarily provide additional protection and because of the added weight may well fail earlier than thinner plaster. It is possible for floors with timber boarded ceilings below to achieve even a full half-hour fire resistance period but this depends on board thickness, tongue size and joint profile, and on the joist size and span. In all constructions the fixing of component parts is critical to the behaviour of the floor when exposed to fire.

It is possible to increase the fire resistance of suitable existing timber floors by certain types of suspended ceiling systems but care is necessary to ensure that the assembly of any proprietary system is strictly in accordance with an appropriate tested specification together with any recommended modifications. In this respect, most fire-protecting suspended ceiling systems have been tested to assess the protection they can give to steel beams under fire resistance test conditions and where assessment of the behaviour under timber floors is possible their contribution is much less because the timber is more vulnerable; added protection is therefore necessary. Test data under BS 476: Part 8 may be unsuitable for assessment purposes where the test was not carried out with furnace pressure conditions appropriate to the integrity criterion.

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Methods

Protection added to the underside of the existing ceiling Table 1 shows the additional protection required for some typical existing ceiling constructions to upgrade the fire resistance to either a half-hour or one hour. Although added layers can increase the performance of a floor, available fixing methods may not be able to carry the extra weight.

Protection applied from above Table 2 gives constructions which can be used if protection must be added from above, for example where an ornate ceiling is to be retained or where access cannot be gained to the storey below. Methods involve either filling between the joists after lifting the floor boards or applying an additional floor finish above the existing boarding, or both. In both the methods of joist infill described, it is essential that the protective material is in intimate contact with the joists to protect them from burning for as long as possible and that the existing ceiling is in a sound condition. It is also important that the added protection is independently fixed and supported, and therefore will not fall when the existing ceiling collapses.

Protection leaving joists exposed below To leave the joists exposed, the recommended protections involve either adding to the flooring above or placing protection between the joists to form an interrupted ceiling, or both.

Joists must be of a size which will enable them to retain structural stability even after some charring of the timber has occurred. Table 3 shows the amount of charring which may occur with different timbers under the heating conditions of the BS 476: Part 8 test and from this the reduction in section size can be calculated. For assessing stability, normal practice applies except that the stresses should not exceed 2.25 times the permissible long-term dry stresses given in CP 112: Part 2 when the minimum initial breadth of the section is 70 mm or greater, or twice the permissible long-term dry stresses when this dimension is less than 70 mm; deflection should not exceed 1/30th of the span. When

Table 1 Additional ceiling protection
(a) Floors with good-fitting, 21 mm tongued and grooved boarding

Required period of fire resistance	Existing ceiling construction	Protection fixed below existing ceiling
half-hour	13 mm fibre insulating board with 5 mm gypsum plaster finish	9.5 mm plaster board
		6 mm asbestos insulating board
one hour	Timber lath and 16 mm plaster	9.5 mm plasterboard with 13 mm lightweight aggregate gypsum plaster finish
		13 mm lightweight aggregate gypsum plaster (metal lathing grade) on metal lath
	9.5 mm plasterboard with skim coat	9.5 mm plasterboard with 13 mm lightweight aggregate gypsum plaster finish
		13 mm lightweight aggregate gypsum plaster (metal lathing grade) on metal lath
		2 layers of 9 mm asbestos insulating board laid to break joint
	12.7 mm plasterboard with skim coat	9.5 mm plasterboard with 13 mm lightweight aggregate gypsum plaster finish
		13 mm lightweight aggregate gypsum plaster (metal lathing grade) on metal lath
		12 mm asbestos insulating board

(b) Floors with plain-edged boarding or badly-fitting tongued and grooved boarding

Required period of fire resistance	Existing ceiling construction	Protection fixed below existing ceiling
half-hour	Timber lath and 16 mm plaster	12.7 mm plasterboard
		6 mm asbestos insulating board
one-hour	Timber lath and 16 mm plaster	13 mm lightweight aggregate gypsum plaster (metal lathing grade) on metal lath
		12 mm asbestos insulating board
	9.5 mm plasterboard with skim coat	9.5 mm plasterboard with 15 mm lightweight aggregate gypsum plaster finish
		12.7 mm plasterboard with 13 mm lightweight aggregate gypsum plaster finish
	12.7 mm plasterboard with skim coat	9.5 mm plasterboard with 15 mm lightweight aggregate gypsum plaster finish
		12.7 mm plasterboard with 13 mm lightweight aggregate gypsum plaster finish
		13 mm lightweight aggregate gypsum plaster (metal lathing grade) on metal lath

Table 1 is applicable only when the floor construction conforms to the dimensions shown in Fig 1
In the case of plaster finishes to lath, the dimensions given are those from the face of the lath.

there is insufficient sacrificial timber to maintain structural stability for the full period of fire resistance, the amount of joist permitted to remain exposed can be reduced by adjusting the position of the ceiling protection relative to the depth of the joists. It is permissible to build up joists to provide sacrificial timber; if this is done, at least ten minutes extra allowance for charring should be provided and the screw fixings should be countersunk at least 6 mm with the holes made good. Table 4 provides information about flooring and protection between joists which will provide either a modified half-hour or a full half-hour floor.

Fixing

Adequate fixing of the additional protection is of paramount importance. When fixing below an existing ceiling, nails or screws must penetrate new work and be driven into the joists to a depth which will ensure that the ceiling remains in place during the intended period of protection. Nailing must be carefully done to minimise damage to the existing ceiling but it must be accepted that some damage will be done, especially to old lath and plaster ceilings. Thus the new work, including fixings, will be supporting some of the weight of the existing ceiling. With lath and plaster ceilings, where the added protection is to incorporate boarding, it is recommended that chicken wire is securely fixed under the existing ceiling by nailing to the joists and the ceiling battened out to receive the new boarded protection. This ensures that should the existing plaster become detached, its weight is not transferred to the added protection. The battens also overcome the problem of an existing uneven plaster surface and will permit the use of conventional fixing techniques. The lengths of nails and screws should be determined according to the method of protection selected. Nails for plasterboard should be galvanised and be of the correct specification where boards are to be plastered. Table 5 gives recommended fixings for plasterboard and asbestos insulating board. The table assumes that the plasterboard is fixed directly to the joists; in practice, therefore, an allowance may have to be made for the thickness of the existing ceiling which in some cases may make this method impracticable. Metal lathing should be fixed at 100 mm centres with galvanised clout headed nails and should be spaced away from the background by some suitable means to give a 6 mm gap. Alternatively, an appropriate proprietary brand should be used.

All new plaster requires a proper key, either plasterboard (or similar) or metal lathing. The use of bonding agents is not recommended in connection with ceilings contributing to the fire resistance of a floor. Although the minimum width of joists (for example) are given, the recommended 'trade' practice should apply in respect of minimal backing, edge clearance of nails, etc.

Table 2 Protection applied from above

Required period of fire resistance	Existing construction		Examples of additional protection: see key below
	Floor boarding	Ceiling	
half-hour	None (eg existing roof space)	9.5 mm plasterboard with skim coat	1
	plain edged	16 mm plaster on wood lath	2
One-hour	21 mm good-fitting tongued and grooved	16 mm plaster on wood lath	3
	plain edged	16 mm plaster on wood lath	2 and 3
	plain edged	9.5 mm plasterboard	2 and 3

Additional protection

1 Not less than 25 mm of mineral fibre insulating material (formed from crushed rock or blast furnace slag) laid between the joists, supported by wire netting placed immediately over the ceiling: the netting to be well turned up and stapled to the joists sides. New floor boarding to be 21 mm good-fitting tongued and grooved

2 Not less than 4.8 mm medium or high density hardboard, or plywood of similar thickness, nailed at not more than 150 mm centres on the line of joists to the existing floor to break joint; joints to coincide with the line of the joists

3 25 mm lightweight aggregate gypsum plaster (metal lathing grade) trowelled between joists in conjunction with expanded metal lathing or chicken wire well turned up and fixed to the joist sides. To prevent staining the existing ceiling, polythene sheet can be placed before the plaster infill.

Note: In methods 1 and 3 the nails or staples should penetrate into the joist sides to a minimum depth of 20 mm

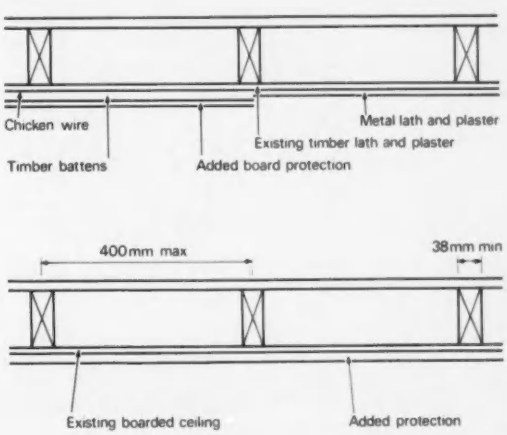

Fig 1 Protection added to underside of existing ceiling

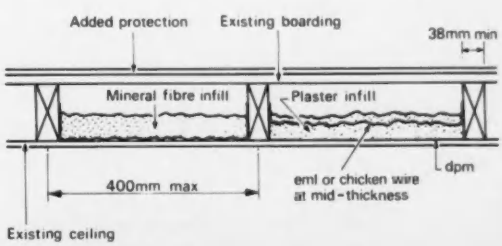

Fig 2 Protection applied from above

Table 3 Charring rates of timber*

Timber	Depth of charring in:	
	30 mins	60 mins
All structural species listed in Table 1 of CP 112: Part 2: 1971, except those listed below.	20 mm	40 mm
Western red cedar	25 mm	50 mm
Oak, utile, keruing (gurjun), teak, greenheart, jarrah	15 mm	30 mm

*From BS 5268: Pt 4: Section 4.1

Provided no dimension is less than 25 mm, a timber joist will char at a steady rate on all faces; the rates in Table 3 apply to each face exposed to fire. Allowance should also be made for increased depth of charring at arrises; this approximates to a radius equal to the calculated depth of charring. However, for periods of 30 minutes or less where the least dimension of residual section is not less than 50 mm, rounding is insignificant and may be disregarded.

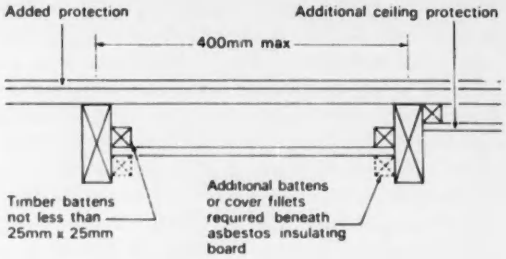
Added protection
Additional ceiling protection
400mm max
Timber battens not less than 25mm x 25mm
Additional battens or cover fillets required beneath asbestos insulating board

Fig 3 Exposed joists

Table 4 Protection leaving joists exposed to view from below

Required period of fire resistance	Construction to provide fire resistance	
	Protection between joists	floor boarding, etc
half-hour modified	9.5 mm plasterboard or 9 mm asbestos insulating board board	21 mm good-fitting t and g boarding
		19 mm wood chipboard or plywood with tongued joints
	12.7 mm plasterboard or 9 mm asbestos insulating board	16 mm good-fitting t and g boarding
half-hour	12.7 mm plasterboard or 9 mm asbestos insulating board	21 mm good-fitting t and g boarding
		19 mm wood chipboard or plywood with tongued joints
	12.7 mm plasterboard with 5 mm gypsum plaster skim coat	15 mm good-fitting t and g boarding
	12.7 mm plasterboard or 9mm asbestos insulating board	Plain-edged boarding with 4.8 mm medium or high density hardboard, or plywood of similar thickness nailed at not more than 150 mm centres on the line of joists to the existing floor to break joint; joints to coincide with the line of the joists.

See Fig 3 for details of joist spacing and battens

Table 5 Recommended fixing for plasterboard with no allowance for existing ceiling

Thickness of plasterboard	Nail length	Spacing
9.5 mm	30 mm	150 mm centres
12.7 mm	40 mm	150 mm centres

For asbestos insulating board, screws should be at centres not exceeding 300 mm and should penetrate the joists by 40 mm.

Asbestos Some of the constructions recommended involve the use of asbestos insulating boards; the Health and Safety Executive issue advice about safety when working with this material. Where the use of one of the new generation of asbestos-free boards is being considered, advice regarding its suitability should be sought from the manufacturer.

Department of the Environment **Building Research Establishment**

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